UNIVERSITY OF MARYLAND
OFFICE OF THE PRESIDENT

Main Administration Building
College Park, Maryland 20742
301.405.5803 TEL 301.314.9560 FAX

February 5, 2020

James D. Fielder, Jr.
Secretary of Higher Education
Maryland Higher Education Commission
6 N. Liberty Street
Baltimore, MD 21201

Dear Secretary Fielder:

I am writing to request approval for a new Bachelor of Science program in Biocomputational Engineering. The proposal for the new program is attached. I am also submitting this proposal to the University System of Maryland for approval.

The proposal was endorsed by the appropriate faculty and administrative committees, and was recommended for approval by the University Senate at its meeting on February 5, 2020. I also endorse this proposal and am pleased to submit it for your approval.

Sincerely,

Wallace D. Loh
President

MDC
cc: Antoinette Coleman, Associate Vice Chancellor for Academic Affairs
Mary Ann Rankin, Senior Vice President and Provost
Darryll Pines, Dean, A. James Clark School of Engineering

Office Use Only: PP#

MHEC
Creating a state of achievement

Cover Sheet for In-State Institutions
New Program or Substantial Modification to Existing Program

Institution Submitting Proposal	University of Maryland, College Park

Each action below requires a separate proposal and cover sheet.

- (●) New Academic Program
- ( ) New Area of Concentration
- ( ) New Degree Level Approval
- ( ) New Stand-Alone Certificate
- ( ) Off Campus Program
- ( ) Substantial Change to a Degree Program
- ( ) Substantial Change to an Area of Concentration
- ( ) Substantial Change to a Certificate Program
- ( ) Cooperative Degree Program
- ( ) Offer Program at Regional Higher Education Center

Payment Submitted: ( ) Yes (●) No | Payment Type: ( ) R*STARS (●) Check | Payment Amount: 850 | Date Submitted:

Department Proposing Program	Fischell Department of Bioengineering	
Degree Level and Degree Type	Bachelor of Science	
Title of Proposed Program	Biocomputational Engineering	
Total Number of Credits	120	
Suggested Codes	HEGIS: 90500.00	CIP: 14.4501
Program Modality	(●) On-campus	( ) Distance Education (*fully online*)
Program Resources	(●) Using Existing Resources	( ) Requiring New Resources
Projected Implementation Date	(●) Fall ( ) Spring ( ) Summer	Year: 2021
Provide Link to Most Recent Academic Catalog	URL: https://academiccatalog.umd.edu/	
Preferred Contact for this Proposal	Name: Michael Colson	
	Title: Senior Coordinator for Academic Programs	
	Phone: (301) 405-5626	
	Email: mcolson@umd.edu	
President/Chief Executive	Type Name: Wallace D. Loh	
	Signature: [signature]	Date: 02/05/2020
	Date of Approval/Endorsement by Governing Board:	

Revised 3/2019

A. Centrality to the University's Mission and Planning Priorities

Description. The fields of Biomedical Engineering and Bioengineering are impacting our society by delivering new imaging and diagnostics technologies, new therapeutic delivery methods, and the possibility of new methods for the repair or construction of tissues and organs. At the same time, computational methods and data science are perfusing into every field of engineering, as well as the life sciences, economics, law, and others. The proposed program aims to provide its students with a foundational breadth in computational bioengineering, which includes strong fundamentals in biology, combined with quantitative problem solving skills. In addition, the program aims to equip its students with applicable skills in data science to position them to contribute to the fields of bioengineering, the biological sciences, and medicine beyond the capabilities of bioengineering and biomedical engineering graduates. As a result, graduates will be well-positioned for rewarding careers while also providing a workforce that will fill needs within the state of Maryland.

A key aspect of the mission of the University of Maryland College Park (UMD) for undergraduate education is that, *"The University will continue to elevate the quality and accessibility of undergraduate education, with programs that are comprehensive and challenging, and that serve students well as a foundation for the workplace, advanced study, and a productive, fulfilling life."* Aligned with this, our program seeks to produce graduates with the preparative foundation in bioengineering and quantitative data science, either for employment or for pursuit of advanced degree educational programs. The University's detailed mission statement continues, focusing on a commitment to *"foster education, critical thinking and intellectual growth, ensuring the knowledge and impact of our graduates are both robust and sustainable."* This aligns closely with our aim to produce graduates with awareness of their field and an understanding of how they can utilize their unique skill sets in bioengineering and data science to address challenges facing society in both the near and long term.

Relation to Strategic Goals. The proposed major in Biocomputational Engineering (ENBC) relates to UMD's strategic goals by adding to its STEM program offerings, most specifically at the Universities at Shady Grove (USG). UMD states the following undergraduate education objective in its *Mission and Goals Statement*: "Increase the number of STEM graduates by creating new programs."

The ENBC program is one of several UMD programs planned for delivery specifically at the Universities at Shady Grove to contribute to workforce development in the state and most specifically in the Montgomery County region, taking advantage of the robust partnership with Montgomery College. USG's mission is *"to support and expand pathways to affordable, high-quality public higher education that meet the distinctive needs of the region and are designed to support workforce and economic development in the state; to achieve these goals through partnerships and collaborations with academic, business, public sector and community organizations that promote student success, high academic achievement and professional advancement.*" This program contributes directly to the goals of access and affordability, to

high quality programming, and to regional and state capacity building, as articulated in USG mission statement.

Funding. Resources for the new program will be drawn from the University System of Maryland's Workforce Development Initiative that was approved by the State Legislature beginning in FY19. Funds were specifically directed to increasing the number of undergraduate degree offerings in STEM areas at the Universities at Shady Grove.

Institutional Commitment. The program will be administered by the Department of Bioengineering within the A. James Clark School of Engineering. Each of UMD's USG programs has an on-site program director. In addition, two staff members are currently in residence at USG to support the program directors in admissions decisions and to provide academic operational support such as recruiting, outreach to community colleges, access to training, and to act as a liaison to academic services on the College Park campus. The University of Maryland (UMD) is also the managing institution for USG, and in that role supports many administrative services for the operation of USG.

B. Critical and Compelling Regional or Statewide Need as Identified in the State Plan

Need. Bioengineering is a growing field, and one that will have a significant impact on society. A need exists for graduates trained in the fundamentals of engineering and life sciences with strong skills in computational methods and data science. A survey of the Bioengineering department's External Advisory Board demonstrated significant enthusiasm for the program's goals of generating graduates with knowledge of life sciences, engineering, programming, and computation. The advisory board rated the demand for these graduates at a score of 4.67 out of 5. The advisory board also emphasized that the Biopharmaceutical industry (which has a strong base in Maryland), the Biomedical Instrumentation industry, and hospitals and insurance companies are currently targeting employees with this skill set.

In recent years the Bioengineering program at UMD has placed about 30% of its graduates into graduate programs, and about 50-60% of its graduates into industry, including biopharmaceutical, biomedical instrumentation, and consulting jobs; nearly all graduates are placed before their graduation day. However, the department's advisory board has communicated that there are additional jobs to be filled, with an emphasis on programming, computation, and data analysis that goes beyond the capabilities of the department's graduates. While graduates in computer science are considered for these jobs, employers in the biopharma and biomedical space prefer multi-disciplinary talents, including fundamental knowledge in life sciences.

While a new program could be launched on the College Park campus, we are proposing to launch the program at USG specifically to target the talented pool of students who complete an engineering program at a community college and aim to work in the biopharma and biomedical industries. By attracting this population into the field, the proposed program will contribute

strongly to the diversity of their employers, which are generally hiring from degree programs lacking in diversity.

State Plan. The proposed program aligns with the *Maryland State Plan for Postsecondary Education* in different ways. First, the program aligns with the state's emphasis on career training and research. Strategy 7 of the *Maryland State Plan* is "Enhance career advising and planning services and integrate them explicitly into academic advising and planning."[1] Career advising will not only be integrated with student advising, it will also be incorporated in the program coursework. All of the core courses for the program will help students achieve this outcome

C. Quantifiable and Reliable Evidence and Documentation of Market Supply and Demand in the Region and State

Analysis of job outlook data from Emsi (https://www.economicmodeling.com/data/) has projected job trends in the field of bioinformatics in the MD/VA/DC region. Note that in the proposed program we use the term "bioinformatics" specifically to imply the analysis of genomic and proteomic data; however, the term is frequently used to describe more generally information science, data analysis, and computation as applied to the life sciences. The analysis suggests that in Maryland, bioinformatics jobs will increase from about 60,000 to about 70,000 between 2018 and 2028, a 16% change (it predicts a 7% regional change and a 16% national change over the same period). Note that this analysis does not include the expected Amazon headquarters in Northern Virginia.

The Emsi report cites Booz Allen Hamilton, Leidos Holdings, and Oracle as likely employers. In addition to Amazon, the department's External Advisory Board has identified the following as employers for the graduates of the proposed program: Becton Dickinson (BD), Roche, Abbott, Beckman, Siemens, GE, Amgen, Kite Pharma, Edwards Life Sciences, numerous hospitals and insurance companies, and most biopharmaceutical companies. In addition, federal and federally-supported laboratories, including NIH, FDA, NRL, NIST, and APL are in need of employees with computational skills and fundamentals in life science and engineering.

D. Reasonableness of Program Duplication

Most closely related to the proposed Biocomputational Engineering program is the Bioengineering program that already exists at College Park (and exists within the same Bioengineering Department as the proposed program). The first half of the program is almost the same, but the second half of the programs differ significantly. The proposed program offers opportunities for training in programming, computational methods, and data science that go well beyond that of a "track" or "specialization." Thus, the graduates from the proposed

[1] Maryland Higher Education Commission. (2017). *Maryland State Plan for Postsecondary Education.* (p. 60). Retrieved October 29, 2018 from: http://www.mhec.state.md.us/About/Documents/2017.2021%20Maryland%20State%20Plan%20for%20Higher%20Education.pdf.

program would be unique in the Clark School.

Bowie State University offers a Bioinformatics degree that has similarities to the proposed program, including the opportunity for training in both the life sciences and computer programming. At the same time, UMGC offers a degree in Biotechnology, while UMBC offers a degree in Translational Life Science Technology at Shady Grove. Some overlap will exist in the skill sets between these graduates and graduates from the proposed program. However, the key difference is that the proposed program is an engineering degree, and thus will emphasize an engineering approach to problem solving above all else.

E . Relevance to Historically Black Institutions (HBIs)

Currently no HBIs offer similar undergraduate programs with the exception of Bowie State University's Bioinformatics program mentioned above. In addition to the aforementioned differences, USG has a regional draw that is rather specific to Central Maryland because of the lack of on-site housing for students. Thus there is not likely to be much overlap in the student populations. Morgan State University offers a Master's program in Bioinformatics, and as a result the program proposed here might serve as a feeder.

F. Relevance to the identity of Historically Black Institutions (HBIs)

The proposed program would not have an impact on the uniqueness or institutional identity of any Maryland HBI, since this program would be a unique offering in the state.

G. Adequacy of Curriculum Design, Program Modality, and Related Learning Outcomes

Curricular Development. The curriculum was developed by faculty of Bioengineering department. All of the undergraduate programs within the A. James Clark School of Engineering are "limited enrollment programs", due to high demand and finite capacity.

The program will be offered exclusively at the Universities at Shady Grove. All undergraduate programs at USG are years 3 and 4 only. Expectations for lower-level coursework will be established through articulation agreements with the Maryland community colleges or taken at College Park prior to admission to the School of Engineering and the major. The proposed curriculum will offer courses at the 300- and 400-level, which constitute the junior and senior year of the program. The program is primarily intended for students transferring from a Maryland public community college. While students at the College Park campus can pursue the program, they will not be able to seek admission into the School of Engineering and the Biocomputational Engineering major until they have completed the Engineering Limited Enrollment Program (LEP) gateway courses, required prior study major courses, lower-level General Education requirements (or an Associate's Degree), and have earned at least 60 credits. Due to the similarity in curriculum content and the physical location of course offerings, students in the Bioengineering program at UMD will not be eligible to add Biocomputational Engineering as a second major or degree (and vice versa).

Faculty Oversight. The faculty within the department of Bioengineering will provide academic direction and oversight for the program. Appendix A contains a list of the BIOE tenured and tenure-track faculty.

Educational Objectives and Learning Outcomes. The educational objectives of the program including the following:

1. Produce graduates with the educational depth, technical skills, and practical experiences to be competitive for placement in Biocomputational Engineering careers or post-graduate educational pursuits;

2. Produce graduates with an awareness of their field and an understanding of how they can address the data-driven computational biomedical challenges facing society in both the near and long term;

3. Produce graduates with a foundation in professional ethics who will actively seek to positively impact their profession, community, and society.

The student learning outcomes are aligned with the outcomes assessed in accordance with the Accreditation Board for Engineering and Technology (ABET) accreditation requirements and include the following. The program must enable students to attain, by the time of graduation:

1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
2. An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.
3. An ability to communicate effectively with a range of audiences.
4. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.
5. An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.
6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.
7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

Institutional assessment and documentation of learning outcomes. Each learning outcome is mapped to one or more courses in the program for assessment. Each course will be assessed once every three years (i.e., twice per ABET cycle) to determine whether the program is achieving each outcome; at least one course will be assessed every year. The assessment will be conducted by the instructor; the instructor will then submit the assessment to the Bioengineering department's Undergraduate Studies Committee. This committee will provide recommendations for modifications to the instructor. The assessment reports follow a template developed by the department.

In addition to the course assessment process, a senior exit survey will be conducted prior to graduation every year. Students will be asked to assess their capabilities related to the seven learning outcomes above. These results will be reviewed by the Undergraduate Studies Committee and recommendations for improvements to the curriculum will be provided to the program's Director as needed.

Course requirements.

FIRST & SECOND YEAR

Prior to being admitted to the Biocomputational Engineering major, students should have completed the Engineering LEP gateway courses, basic math/science courses, and lower-level General Education requirements. Below is the representative set of requirements; specific articulation agreements will be established with each of the local community colleges.

Course	**Title**	**Cr**
ENGL 101	Academic Writing	3
MATH 140	Calculus I	4
MATH 141	Calculus II	4
MATH 241	Calculus III	4
MATH 246	Differential Equations for Scientists and Engineers	3
CHEM 135/136	General Chemistry for Engineers (plus lab)	4
CHEM 231/232	Organic Chemistry (plus Laboratory)	4
PHYS 161	General Physics: Mechanics and Particle Dynamics	3
PHYS 260/261	General Physics: Vibration, Waves, Heat, Electricity and Magnetism (plus Laboratory)	4
ENES 100	Introduction to Engineering Design	3
BSCI 170 OR BIOE 120	Principles of Molecular & Cellular Biology OR Biology for Engineers	3
BIOE 241	Matlab Programming Course (or equivalent)	3
GenEd Courses	General Education Requirements	18
	Total Credits	**60**

JUNIOR & SENIOR YEARS AT SHADY GROVE

Junior Year 1st Semester

Course	Title	Cr
ENBC 301	Introduction to Biocomputational Engineering	1
ENBC 311	Python for Data Analysis	3
ENBC 331	Applied Linear Systems and Differential Equations	3
ENBC 332	Statistics, Data Analysis, and Data Visualization	3
ENBC 341	Biomolecular Engineering	3
ENBC 351	Quantitative Molecular and Cell Biology	3
	Total Semester Credits	**16**

Junior Year 2nd Semester

Course	Title	Cr
ENBC 312	Object Oriented Programming in C++	3
ENBC 322	Algorithms	3
ENBC 342	Computational Fluid Dynamics and Mass Transfer	3
ENBC 352	Molecular Techniques Laboratory	2
	Elective	3
	Total Semester Credits	**14**

Senior Year 1st Semester

Course	Title	Cr
ENBC 321	Machine Learning for Data Analysis	3
ENBC 353	Synthetic Biology	3
ENBC 431	Finite Element Analysis	3
ENGL 393	Professional Writing	3
	Elective	3
	Total Semester Credits	**15**

Senior Year 2nd Semester

Course	Title	Cr
ENBC 425	Imaging and Image Processing	3
ENBC 441	Computational Systems Biology	3
ENBC 491	Senior Capstone Design in Biocomputational Engineering	3
	Two Electives	6
	Total Semester Credits	**15**

TOTAL DEGREE CREDITS	**120**

Students are required to take four technical electives. The courses must be selected from an approved list of engineering and biology courses; the list will be updated regularly by the Program Director. At least two of the elective courses must be from the category of engineering, mathematics, or programming, while at most two of the electives can be from the category of biology courses. The program will offer electives; at the same time, the program will arrange for opportunities for electives outside the program, including USG programs offered by other universities.

See Appendix B for course descriptions.

General Education. Students will complete their science and mathematics general education requirements by way of fulfilling major requirements. Students who transfer to UMD with an Associate's degree from a Maryland community college are deemed to have completed their General Education requirements with the exception of Professional Writing, which is typically taken in their third year of study.

Accreditation or Certification Requirements. As with other undergraduate Engineering degree programs at UMD, the Clark School of Engineering will seek to have this program accredited by the Accreditation Board of Engineering and Technology (ABET).

Other Institutions or Organizations. The department will not contract with another institution or non-collegiate organization for this program.

Student Support. To fully serve the academic and support needs of the Biocomputational Engineering students, the program will employ one full-time academic advisor at Shady Grove. Anticipating student growth, additional part-time or full-time advisors will be needed in subsequent years. All academic advisors will report directly to the Fischell Department of Bioengineering Associate Director of Academic and Student Affairs. Academic advisors at Shady Grove will manage course scheduling, perform academic advising each semester, track degree requirements, and provide academic and support resources when appropriate. The academic advising team will also assist in outreach efforts and building a strong community among prospective and current students. Additionally, the Biocomputational Engineering major will identify a Faculty Program Director who will reside at Shady Grove at least two days per week. The Faculty Program Director will work closely with the UMD liaisons as well as all tenure-track (TTK) and professional-track (PTK) faculty in addressing student and instructor concerns, developing electives, and performing assessment measures.

Additional services are provided for all programs at the Universities at Shady Grove through USG's Center for Academic Success.

Marketing and Admissions Information. The department will produce marketing materials and will conduct recruitment events at various times in the year. Admissions will be administered by UMD's Undergraduate Admissions Shady Grove Coordinator and the Biocomputational Engineering Program Director. Following procedures previously established at the Universities

at Shady Grove, the Clark School's Assistant Director of Transfer Student Advising and Admissions will review the accepted Biocomputational Engineering cohort to ensure all students meet the Clark School's LEP admission criteria. It is expected that admissions will require only a minimal burden upon the Clark School staff and the Fischell Department of Bioengineering staff.

H. Adequacy of Articulation

Montgomery College is expected to be the largest feeder, although students who have completed two years in any engineering program in a Maryland Community College will be eligible for admission provided they meet the program's eligibility requirements. The Clark School's requirements for transfer students are articulated with the Montgomery College Associate of Science in Engineering. Montgomery College students can enter the program upon completing the Bioengineering focus at Montgomery College with a few substitutions that will be communicated between the Bioengineering Department and Montgomery College. The pathway to articulation into the current Bioengineering degree is articulated through Montgomery College's Associate of Science in Engineering, Bioengineering. In addition to the community college population, current students within the Clark School of Engineering are eligible to change majors into the Biocomputational Engineering Program; in particular, students from the Bioengineering major will meet the requirements upon completion of the sophomore year.

I. Adequacy of Faculty Resources

Program faculty. Appendix A contains a full list of Bioengineering department faculty. It is expected that two TTK faculty and four PTK lecturers will represent the program at USG. This is sufficient to provide 8 courses per semester, which enables coverage of all of the planned ENBC courses (the program requires sixteen ENBC courses, but three of those are 1 credit only). Adjunct faculty may also be contracted to cover courses as needed. Class sizes are expected to be on the order of 30 students, and thus teaching assistants will not be needed. Undergraduate Teaching Fellows (senior students in the program) will be used to support courses when possible.

Faculty training. All faculty will receive guidance from the Bioengineering Department, which considers teaching to be critical to the success of its program. For the learning management system, faculty teaching in this program will have access to instructional development opportunities available across the College Park campus, including those offered as part of the Teaching and Learning Transformation Center. For online elements of the coursework, instructors will work with the learning design specialists on campus to incorporate best practices when teaching in the online environment.

J. Adequacy of Library Resources

The University of Maryland Libraries has conducted an assessment of library resources required for this program. The assessment concluded that the University Libraries are able to meet, with its current resources, the curricular and research needs of the program. Resources are available locally at USG's Priddy Library as well as on the College Park campus.

K. Adequacy of Physical Facilities, Infrastructure, and Instructional Resources

The program will be delivered in the new Biomedical Sciences and Engineering Education (BSE) building (also called Building IV) at the Universities at Shady Grove. This state-of-the-art educational facility has a suite of shared active-learning classrooms, computing resources, wet labs, a dental clinic, product design laboratory and maker space, as well as offices for faculty and staff delivering the curricula and student support services. The ENBC program expects to have 1-2 dedicated laboratory spaces for its programmatic needs.

L. Adequacy of Financial Resources

Resources for the program will come from tuition revenue and from the Governor's Workforce Development Initiative funds that were specifically directed towards implementation of STEM degree programs at the Universities at Shady Grove. Students in this program will represent new enrollment at UMD the tuition revenue associated with this enrollment will be directed towards program needs. Tuition revenue alone is not adequate to support the program; UMD, USG and USM have articulated a memorandum of understanding to maintain funding for the program, beyond revenue expected from tuition. See Tables 1 and 2 for anticipated resources and expenditures.

M. Adequacy of Program Evaluation

Formal program review is carried out according to the University of Maryland's policy for Periodic Review of Academic Units, which includes a review of the academic programs offered by, and the research and administration of, the academic unit (http://www.president.umd.edu/policies/2014-i-600a.html). Program Review is also monitored following the guidelines of the campus-wide cycle of Learning Outcomes Assessment (https://www.irpa.umd.edu/Assessment/LOA.html). Faculty within the department are reviewed according to the University's Policy on Periodic Evaluation of Faculty Performance (http://www.president.umd.edu/policies/2014-ii-120a.html). Since 2005, the University has used an online course evaluation instrument that standardizes course evaluations across campus. The course evaluation has standard, university-wide questions and also allows for supplemental, specialized questions from the academic unit offering the course.

N. Consistency with Minority Student Achievement goals

An important aspect of this program is to draw upon students in the community colleges, which have traditionally large numbers of African and Latino Americans, and thereby improving the

numbers of underrepresented minorities in STEM education. This will be a factor in student recruitment.

O. Relationship to Low Productivity Programs Identified by the Commission

N/A

P. Adequacy of Distance Education Programs

N/A

Tables 1 and 2: Resources and Expenditures

TABLE 1: RESOURCES

Resources Categories	Year 1	Year 2	Year 3	Year 4	Year 5
1.Reallocated Funds	$0	$0	$0	$0	$0
2. Tuition/Fee Revenue (c+g below)	$233,600	$481,216	$867,392	$1,021,044	$1,051,675
a. #FT Students	20	40	70	80	80
b. Annual Tuition/Fee Rate	$11,680	$12,030	$12,391	$12,763	$13,146
c. Annual FT Revenue (a x b)	$233,600	$481,216	$867,392	$1,021,044	$1,051,675
d. # PT Students	0	0	0	0	0
e. Credit Hour Rate	$485.00	$499.55	$514.54	$529.97	$545.87
f. Annual Credit Hours	16	16	16	16	16
g. Total Part Time Revenue (d x e x f)	$0	$0	$0	$0	$0
3. Grants, Contracts, & Other External Sources	$0	$0	$0	$0	$0
4. Other Sources	$900,000	$900,000	$900,000	$900,000	$900,000
TOTAL (Add 1 - 4)	**$1,133,600**	**$1,381,216**	**$1,767,392**	**$1,921,044**	**$1,951,675**

Tuition revenue is based on AY2019-20 rates for the A. James Clark School of Engineering. It does not include mandatory fees or laboratory fees. Reallocated funds assume support from the States Workforce Development Initiative targeted towards programs to be delivered at the Universities at Shady Grove.

TABLE 2: EXPENDITURES

Expenditure Categories	Year 1	Year 2	Year 3	Year 4	Year 5
1. Full time Faculty (b+c below)	$399,000	$547,960	$705,499	$871,996	$898,156
a. #FTE	3.0	4.0	5.0	6.0	6.0
b. Total Salary	$300,000	$412,000	$530,450	$655,636	$675,305
c. Total Benefits	$99,000	$135,960	$175,049	$216,360	$222,851
2. Part time Faculty (b+c below)	$12,000	$24,000	$60,000	$60,000	$60,000
a. #FTE	0.2	0.4	1.0	1.0	1.0
b. Total Salary	$12,000	$24,000	$60,000	$60,000	$60,000
c. Total Benefits	$0	$0	$0	$0	$0
3. Admin. Staff (b+c below)	$186,200	$191,786	$246,924	$254,332	$261,962
a. #FTE	2.0	2.0	2.5	2.5	2.5
b. Total Salary	$140,000	$144,200	$185,658	$191,227	$196,964
c. Total Benefits	$46,200	$47,586	$61,267	$63,105	$64,998
4. Technical Support staff (b+c below)	$53,200	$54,796	$56,440	$58,133	$59,877
a. #FTE	0.5	0.5	0.5	0.5	0.5
b. Total Salary	$40,000	$41,200	$42,436	$43,709	$45,020
c. Total Benefits	$13,200	$13,596	$14,004	$14,424	$14,857
5. Graduate Assistants (b+c below)	$26,600	$53,200	$53,200	$53,200	$53,200
a. #FTE	1.0	2.0	2.0	2.0	2.0
b. Stipend	$20,000	$40,000	$40,000	$40,000	$40,000
c. Tuition Remission + benefits	$6,600	$13,200	$13,200	$13,200	$13,200
6. Equipment	$50,000	$25,000	$25,000	$25,000	$25,000
7. Library	$5,000	$5,000	$5,000	$5,000	$5,000
8. New or Renovated Space	$0	$0	$0	$0	$0
9. Marketing/Advertising	$5,000	$5,000	$5,000	$5,000	$5,000
10. Other Expenses: Operational Expenses	$50,000	$50,000	$50,000	$50,000	$50,000
11. Office Space Rental	$10,500	$10,815	$11,139	$11,474	$11,818
12. Classroom Rental	$0	$9,000	$9,270	$9,548	$9,835
13. university administrative fee	$23,360	$48,122	$86,739	$102,104	$105,168
TOTAL (Add 1 - 13)	**$820,860**	**$1,024,679**	**$1,314,211**	**$1,505,788**	**$1,545,015**

Notes: Graduate assistants are included in the budget to support instruction; however if the class sizes are as anticipated, it is more likely that the department will use undergraduate teaching assistants which will change the budget slightly. Other expenses include tuition remission for graduate assistants, lab equipment and software maintenance, materials and supplies, program outreach, and travel related to the program.

Appendix A: Faculty in the Fischell Department of Bioengineering

All faculty hold doctoral degrees in a field relevant to the discipline. Faculty biographies and research interests can be found in the department's web site (https://bioe.umd.edu/clark/facultydir?drfilter=1). All faculty listed are full-time. Specific course assignments have not yet been made, but will be made in time to schedule the courses for the target start term of Fall 2021. Some additional hires are anticipated to support the program at Shady Grove.

Faculty Name	Highest Degree Earned - Field and Year	Rank
Aranda-Espinoza, Helim	Ph.D., Physics, 1998	Associate Professor and Associate Chair
Bentley, William	Ph.D., Chemical Engineering, 1989	Fischell Distinguished Professor
Clyne, Alisa	Ph.D., Medical and Mechanical Engineering, 2006	Associate Professor
Duncan, Gregg	Ph.D., Chemical and Biomolecular Engineering, 2014	Assistant Professor
Eisenstein, Edward	Ph.D., Biochemistry, 1985	Associate Professor
Fisher, John	Ph.D., Bioengineering, 2003	Fischell Distinguished Prof and Chair
He, Xiaoming	Ph.D., Mechanical Engineering, 2004	Professor
Huang, Huang-Chiao	Ph.D., Chemical Engineering, 2012	Assistant Professor
Jay, Steven	Ph.D., Biomedical Engineering, 2009	Associate Professor
Jewell, Christopher	Ph.D., Chemical Engineering, 2008	Minta Martin Professor of Engineering and Associate Professor/Chair
Jones, Angela	Ph.D., Chemical Engineering, 2010	Senior Lecturer
Ma, Lan	Ph.D., Electrical & Computer Engineering, 2004	Lecturer
Maisel, Katharina	Ph.D., Biomedical Engineering, 2014	Assistant Professor
Matysiak, Silvina	Ph.D., Chemistry, 2007	Associate Professor
Montas, Hubert	Ph.D., Agricultural and Biological Engineering, 1996	Associate Professor
Pranda, Marina	Ph.D., Bioengineering, 2019	Lecturer
Scarcelli, Giuliano	Ph.D., Applied Physics, 2006	Assistant Professor
Stroka, Kimberly	Ph.D., Bioengineering, 2011	Assistant Professor
Tao, Yang	Ph.D., Biological Engineering, 1991	Professor
White, Ian	Ph.D., Electrical Engineering, 2002	Associate Professor and Associate Chair
Zhang, Li-Qun	Ph.D., Biomedical Engineering, 1990	Professor

Appendix B: Course Descriptions

Some courses will be new to this program; they will be approved through the university's standard course approval process prior to delivery.

ENBC301: Introduction to Biocomputational Engineering
Credits: 1
Grading method: regular
Prerequisites: none
Restriction: Permission of ENGR-Fischell Department of Bioengineering department; and must be in Biocomputational Engineering major.
Description: Provides practical tools to help Biocomputational Engineering majors to think critically about their goals and career paths and to utilize their major to set their career trajectory.

ENBC311: Python for Data Analysis
Credits: 3
Grading method: regular
Prerequisites: none
Restriction: Permission of ENGR-Fischell Department of Bioengineering department; and must be in the Biocomputational Engineering major.
Credit only granted for: BIOE489A or BIOE442 or ENBC311.
Description: Provides an introduction to structured programming, computational methods, and data analysis techniques with the goal of building a foundation allowing students to confidently address problems in research and industry. Fundamentals of programming, algorithms, and simulation are covered from a general computer science perspective, while the applied data analysis and visualization portion makes use of the Python SciPy stack.

ENBC312: Object Oriented Programming in C++
Credits: 3
Grading method: regular
Prerequisites: none
Restriction: Permission of ENGR-Fischell Department of Bioengineering department; and must be in the Biocomputational Engineering major.
Description: Provides an introduction to object oriented programming in the C++ language.

ENBC321: Machine Learning for Data Analysis
Credits: 3
Grading method: regular
Prerequisites: completion of ENBC312 and ENBC332 with a grade of "C-" or better.
Restriction: Permission of ENGR-Fischell Department of Bioengineering department; and must be in the Biocomputational Engineering major.
Description: Provides an introduction to artificial intelligence methods for mining big data sets and for making decisions using data sets.

ENBC322: Algorithms
Credits: 3
Grading method: regular
Prerequisites: completion of ENBC311 with a grade of "C-" or better.
Restriction: Permission of ENGR-Fischell Department of Bioengineering department; and must be in the Biocomputational Engineering major.
Credit only granted for: ENEB355 or ENBC322.
Description: Utilizing the Python programming language for a systematic study of the complexity of algorithms related to sorting, graphs and trees, and combinatorics. Algorithms are analyzed using mathematical techniques to solve recurrences and summations.

ENBC331: Applied Linear Systems and Differential Equations
Credits: 3
Grading method: regular
Prerequisites: completion of MATH246 and Matlab prior study requirement with a grade of "C-" or better. Restriction: Permission of ENGR-Fischell Department of Bioengineering department; and must be in the Biocomputational Engineering major.
Credit only granted for: BIOE371 or ENBC331.
Description: Applications of linear algebra and differential equations to bioengineering and biomolecular systems. Designed to instruct students to relate mathematical approaches in bioengineering to their physical systems. Examples will emphasize fluid mechanics, mass transfer, and physiological systems.

ENBC332: Statistics, Data Analysis, and Data Visualization
Credits: 3
Grading method: regular
Prerequisites: none
Restriction: Permission of ENGR-Fischell Department of Bioengineering department; and must be in the Biocomputational Engineering major.
Credit only granted for: BIOE372 or ENBC332 or STAT464.
Description: This course will instruct students in the fundamentals of probability and statistics through examples in biological phenomenon and clinical data analysis. Data visualization strategies will also be covered.

ENBC341: Biomolecular Engineering Thermodynamics
Credits: 3
Grading method: regular
Prerequisites: completion of MATH246 and PHYS260 with a grade of "C-" or better.
Restriction: Permission of ENGR-Fischell Department of Bioengineering department; and must be in the Biocomputational Engineering major.
Credit only granted for: BIOE232 or ENBC341 or CHBE301.
Description: A quantitative introduction to thermodynamic analysis of biomolecular systems. The basic laws of thermodynamics will be introduced and explained through a series of

examples related to biomolecular systems.

ENBC342: Computational Fluid Dynamics and Mass Transfer
Credits: 3
Grading method: regular
Prerequisites: completion of ENBC341 and Matlab prior study requirement with a grade of "C-" or better; and must have completed (with a grade of "C-" or better) or be concurrently enrolled in ENBC331.
Restriction: Permission of ENGR-Fischell Department of Bioengineering department; and must be in the Biocomputational Engineering major.
Credit only granted for: BIOE331 or ENBC342.
Description: Principles and applications of fluid mechanics and mass transfer with a focus on topics in the life sciences and an emphasis on computational methods and modeling. Content includes conservation of mass, momentum, and energy, as well as the application of these fundamental relations to hydrostatics, controlvolume analysis, internal and external flow, and boundary layers. Applications to biological and bioengineering problems such as tissue engineering, bioprocessing, imaging, and drug delivery.

ENBC351: Quantitative Molecular and Cellular Biology
Credits: 3
Grading method: regular
Prerequisites: Completion of BSCI170 prior study with a grade of "C-" or better. Co-requisites: none
Restriction: Permission of ENGR-Fischell Department of Bioengineering department; and must be in the Biocomputational Engineering major.
Description: Quantitative analysis of the behavior of cellular and molecular systems.

ENBC352: Molecular Techniques Laboratory
Credits: 2
Grading method: regular
Prerequisites: Must have completed (with a grade of "C-" or better) or be concurrently enrolled in ENBC351. Restriction: Permission of ENGR-Fischell Department of Bioengineering department; and must be in the Biocomputational Engineering major.
Description: Wet lab experiments to observe cellular and molecular processes and phenomenon.

ENBC353: Synthetic Biology
Credits: 3
Grading method: regular
Prerequisites: Completion of BSCI170 prior study with a grade of C- or better.
Restriction: Permission of ENGR-Fischell Department of Bioengineering department; and must be in the Biocomputational Engineering major.
Credit only granted for: BIOE461 or ENBC353.
Description: Students are introduced to the scientific foundation and concepts of synthetic

biology and biological engineering. Current examples that apply synthetic biology to fundamental and practical challenges will be emphasized. The course will also address the societal issues of synthetic biology, and briefly examine interests to regulate research in this area.

ENBC411: Advanced Programming in Python
Credits: 3
Grading method: regular
Prerequisites: completion of ENBC311 with a grade of "C-" or better.
Restriction: Permission of ENGR-Fischell Department of Bioengineering department; and must be in the Biocomputational Engineering major.
Description: Advanced programming methods with an emphasis on biocomputational applications.

ENBC413: Data Analysis with R
Credits: 3
Grading method: regular
Prerequisites: completion of ENBC332 with a grade of "C-" or better.
Restriction: Permission of ENGR-Fischell Department of Bioengineering department; and must be in the Biocomputational Engineering major.
Description: Provides an introduction to programming techniques for data analysis with the statistical software "R."

ENBC425: Imaging and Image Processing
Credits: 3
Grading method: regular
Prerequisites: completion of ENBC321 with a grade of "C-" or better.
Restriction: Permission of ENGR-Fischell Department of Bioengineering department; and must be in the Biocomputational Engineering major.
Description: Examines the physical principles behind major biomedical imaging modalities, including X-Ray, CT, MRI. Instructs students in mathematical tools for extracting information from images. Provides an introduction to the use of machine learning for interpreting images. Matlab and/or Python utilized for image processing exercises.

ENBC431: Finite Element Analysis
Credits: 3
Grading method: regular
Prerequisites: completion of MATH246 with a grade of "C-" or better.
Restriction: Permission of ENGR-Fischell Department of Bioengineering department; and must be in the Biocomputational Engineering major.
Description: Instructs students to use computer tools to analyze the thermal and mechanical properties of devices or systems. The course will focus specifically on the biomechanics of biomedical devices.

ENBC435: Numerical Methods
Credits: 3
Grading method: regular Prerequisites: none
Restriction: Permission of ENGR-Fischell Department of Bioengineering department; and must be in the Biocomputational Engineering major.
Description: The review of numerous mathematical methods to simplify complex problems.

ENBC441: Computational Systems Biology
Credits: 3
Grading method: regular
Prerequisites: completion of ENBC351 with a grade of "C-" or better.
Restriction: Permission of ENGR-Fischell Department of Bioengineering department; and must be in the Biocomputational Engineering major.
Description: Introduction to building computer models that analyze dynamic functions within a cell, organ, tissue, or organism.

ENBC442: Computational Molecular Dynamics
Credits: 3
Grading method: regular
Prerequisites: completion of ENBC341 and ENBC332 with a grade of "C-" or better.
Restriction: Permission of ENGR-Fischell Department of Bioengineering department; and must be in the Biocomputational Engineering major.
Credit only granted for: BIOE464 or ENBC442.
Description: Designed to introduce students to the principles, methods, and software used for simulation and modeling of macromolecules of biological interest such as proteins, lipids, and polysaccharides. Class topics: Basic statistical thermodynamics, force fields, molecular dynamics/ monte carlo methods, conformational analysis, fluctuations & transport properties, free-energy calculations, multiscale modeling.

ENBC443: Multiscale Simulation Methods
Credits: 3
Grading method: regular
Prerequisites: completion of ENBC341 and ENBC332 with a grade of "C-" or better.
Restriction: Permission of ENGR-Fischell Department of Bioengineering department; and must be in the Biocomputational Engineering major.
Credit only granted for: BIOE463 or ENBC443.
Description: Introduction to approaches to modeling a system at different scales, such as atomic, molecular, and macromolecular. Examples will focus on proteins for which models include the interactions with water, atomic interactions within the molecule, and interactions between multiple molecules; models that span both short and long time scales are also studied.

ENBC444: Modeling Protein Folding
Credits: 3
Grading method: regular

Prerequisites: completion of ENBC341 and ENBC332 with a grade of "C-" or better.
Restriction: Permission of ENGR-Fischell Department of Bioengineering department; and must be in the Biocomputational Engineering major.
Description: Computational prediction of the structure of proteins with applications in protein misfolding diseases such as Alzheimer's Disease and other prion diseases.

ENBC445: Spatial Control of Biological Agents
Credits: 3
Grading method: regular
Prerequisites: completion of ENBC342 with a grade of "C-" or better.
Restriction: Permission of ENGR-Fischell Department of Bioengineering department; and must be in the Biocomputational Engineering major.
Description: Description and solution of the movement of passive and active biological agents in homogeneous and heterogeneous bioenvironments using partial differential equations and numerical methods. Identification and diagnosis of hot spots. Prescription of control strategies using techniques from Artificial Intelligence (AI) and verification of effectiveness. Applications environments may include landscapes and tissues.

ENBC455: Bioinformatics Engineering
Credits: 3
Grading method: regular
Prerequisites: completion of ENBC311 with a grade of "C-" or better.
Restriction: Permission of ENGR-Fischell Department of Bioengineering department; and must be in the Biocomputational Engineering major.
Description: Introduces students to core problems in bioinformatics, along with databases and tools that have been developed to study them. Students will learn to utilize Python to process data sets.

ENBC491: Senior Capstone Design in Biocomputational Engineering
Credits: 3
Grading method: regular
Prerequisites: completion of 18 credits in ENBC courses.
Restriction: Permission of ENGR-Fischell Department of Bioengineering department; and must be in the Biocomputational Engineering major.
Description: Senior design project, in which students work in teams to utilize the skills acquired through the major to identify and solve quantitative problems in bioengineering. Ethics in bioengineering and biotechnology will also be covered.

ENGL393: Technical Writing
Credits: 3
Grading method: regular Prerequisites: ENGL101.
Restriction: Must have earned a minimum of 60 credits. Description: The writing of technical papers and reports.